Geology and genesis of the Ridgeway porphyry Au-Cu deposit, NSW

by

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Submitted in fulfilment of the requirements for the degree of

Doctor of Philosphy

University of Tasmania

November, 2010

University of Tasmania

ARC Centre of Excellence in Ore Deposits

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Abstract

The Ridgeway alkalic porphyry Au–Cu deposit is located in the Molong Volcanic Belt of the Macquarie Arc, part of the Lachlan Fold Belt in eastern Australia. Ridgeway is hosted by a Middle Ordovician sequence of volcano-sedimentary rocks that were deposited in an active submarine sedimentary basin. The volcanic sequence evolved from fine grained distal volcaniclastics (Weemalla Formation) to coarse proximal breccias and sandstones (Forest Reef Volcanics). The host sequence was intruded first by pyroxene- and feldspar-phyric dikes and sills, and then by the Ridgeway intrusive complex, a cluster of subvertical porphyry pipes, dikes and stocks of monzodiorite (U–Pb$_{zircon}$ age: 448.2 ± 2.1 Ma), mafic monzonite and quartz monzonite (U–Pb$_{zircon}$ age: 444.2 ± 1.3 Ma). Cross-sectional shapes of the monzonite intrusions are broadly pipe-like. They swell at the contact between the Weemalla Formation and Forest Reef Volcanics.

The highest Au–Cu grades at Ridgeway are associated with quartz–magnetite–bornite vein stockworks and intense K-silicate alteration that formed during the emplacement of the mafic monzonite. These early stage veins have been truncated by the quartz monzonite porphyry and its lower grade quartz–chalcopyrite ± molybdenite veins (Re–Os$_{molybdenite}$: 445.7 ± 2.8 Ma, 442.8 ± 2.3 Ma) associated with less intense K-silicate alteration. A late-stage quartz monzonite cut the earlier phases, and defines the low-grade core of the deposit.

The mafic monzonite and quartz monzonite contain magnetite- and quartz-rich unidirectional solidification textures (USTs), miarolitic cavities and aplite vein-dikes. These textural features imply that magmatic-hydrothermal fluids streamed through and accumulated within the narrow pipes, which acted as a conduit to supply fluids from a deeper magma to the site of ore deposition. Mineralizing fluids were released when the carapace of the crystallizing fluids failed, and were emplaced preferentially into two subvertical vein systems that formed via hydraulic fracturing.

The older veins (set 2) strike N, WNW and NE, whereas the younger mineralized structures (set 3) strike E, NE and NW.

Cathodoluminescence imaging of quartz shows that most of the quartz (Qz-1) crystallized early in the history of vein formation. Dissolution of Qz-1 was then followed by the deposition of a second quartz generation (Qz-2). Cu–Fe sulfides were then deposited together with a later generation of darkly-luminescent quartz (Qz-3). Bright luminescence in Qz-1 correlates with elevated Al, Ti and K concentrations, whereas dull-luminescent Qz-3 is comparatively rich in Fe. High-temperature Qz-1 precipitated during vein stockwork formation at temperatures between 601º and 850ºC in equilibrium with hydrothermal K-feldspar. Changes in pressure and temperature occurred during mechanical fracturing that created secondary permeability exploited by Qz-2. Further decrease in pressure and/or temperature facilitated the precipitation of Qz-3 at temperatures below 589ºC, synchronous with Fe–Cu sulfides.

Sulfur isotopic compositions of sulfides from Ridgeway show increasing $\delta^{34}S$ depletion in the sequence of pyrite (ave. -1.8 ‰), chalcopyrite (ave. -3.6 ‰) and bornite (ave. -4.9 ‰). Low $\delta^{34}S_{bornite}$ and $\delta^{34}S_{chalcopyrite}$ values occur in the core of the deposit. Isotopically light $\delta^{34}S_{pyrite}$ values are also found in the core of the deposit, but these become more negative towards the top of the deposit, in the epidote–chlorite–hematite alteration zone. This is consistent with isotopic fractionation caused by cooling of the magmatic-hydrothermal fluids under oxidizing conditions during late-stage pyrite deposition.

The Ridgeway deposit was localized at the intersection of NW-trending faults and a NNW-trending monocline. The pre-existing NW-trending parallel wedge-shape faults provided the pathways for the deep-seated magma to migrate into the shallow crust. Roof-lifting within the fault wedge provided space for monzonite emplacement. At Ridgeway, there was an intimate link between magmatism and a dynamic structural environment that ultimately controlled the genesis of the high-grade orebody and provided an excellent focus for fluid flow in a well-developed vein stockwork.

Acknowledgements

First and foremost, I would like to thank my husband, Al, for all the support, encouragement, love and understanding over the years of this study. You have given up so much for me to pursue my dreams, for this I am truly grateful. To our children, Lean and Aaron, thank you for your understanding....…now the fun part begins.

To my supervisor, Dave Cooke, I would like to extend my sincerest thanks and appreciation, not only for initiating this project in collaboration with Newcrest, but for your support and patience over the years. Thank you Dave for showing little restraint when it came to editing my drafts - for your dedication to enforce the rudiments of the English language, and for your perseverance to instil in your student the importance of technical syntax. Thank you for imparting your expertise - I have learned a lot through the years, for which I am extremely grateful.

I would like to thank my two co-supervisors, Anthony Harris and Ron Berry for providing sound technical input. Thanks Anthony for introducing me to the enigmatic mushy-features of magma. And Ron, thank you for sharing your expertise and providing numerous edits of my structural model. Sincere thanks to Richard Tosdal for his help and patience in explaining the complexities of structures in the field.

Many thanks are extended to Newcrest Mining Limited and the ARC Centre of Excellence in Ore Deposit Research for the financial, technical and logistical support of this research project. Additional research fund also came from the SEG Foundation-McKinstry grant.

Special thanks go to Newcrest geoscientists John Holliday, Ian Tedder, Dean Collett, Collin McMillan, Geoff Smart, among others for the support on the different aspects of the study. Matt Hatzl, Katrina Thiel, Robyn Ransley, Caroline Hassall, and the Rockdoctors are thanked for logistic support extended in the field. Special thanks go to Dave Coates, Raquel Kolkert, Megan Evitt and John Chow, and Lea for being especially hospitable during my stay in Orange. Many thanks to Mark Gabbitus for allowing to me use the MineSight software.

I would like to extend my gratitude and appreciation to the academic staffs at CODES which provided expert advice during the course of this study: Tony Crawford for the insightful discussion on my whole rock geochemistry; Garry Davidson for the sulfur isotope 101 lectures and discussions on my isotope data; Sebastien Mefree for his help in concordia plots; and Zhaoshan Chang for always being there, not only as a friend, but also for sharing his expertise on skarn. Karsten Goemann at the CSL is thanked for his assistance in the microprobe.

Big thanks to Jocelyn McPhie, Karin Orth, Isabelle Chamberfort, David Hutchinson and Huayong Chen for the encouragement. Joce – thanks a lot for everything. To Julie Hunt, I cannot thank you enough for all your help to me and my family – it is greatly appreciated.

I wish to thank the School of Earth Sciences support staffs: Simon Stephens for processing my samples, Peter Cornish for the help when we were re-arranging our office (I still use a stool when trying to reach things), Dianne Madden for the help in the admin, Christine Higgins, Helen Scott, Karen Molross and Dianne Steffens, for taking care of the financial aspects (and saved me the worry of financial crisis), Isabella von Lichtan, for the expert advice in taking rock pictures, Sarah Gilbert, for her assistance on trace element mapping, and Keith Dobson, for all the technical support. Special thanks to June Pongratz in the editorial side of this thesis.

To my current and former postgraduate colleagues, thank you for the friendship, support and conversation: Bronto, Taka, Sang, Nathan, Anita, Joe, Ben, Tim, Patrick, Claire (thanks for the wool blanket), Hugo, Andrea, Adam, Sarah, Martin, Heidi, Sofia, Natalee, Olga, Adel, Kyrill and Roisin. Special thanks to Wojciech, Masoe, Jacq, Gisela and Fiona for all the advice and encouragement, especially on the final months in writing my thesis.

Finally, I would like to thank my mother, sisters, brother and in-laws for all the encouragement and support over the years.

To my late father and sister………I made it.

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